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Patent application

Process for the Production of a Tube Unit

The invention relates to a process for the production of a tube unit.

The objective consists of holding several tubes coaxial to one another in a simple manner so that a good heat exchange can take place between several fluids flowing through the tubes or along them. This objective is realized by the processing steps characterized in Claim 1.

In a tube unit produced according to the process according to the invention, the inner of two concentric tubes is corrugated and consists of ridges directed radially outwards and that abut the inner surface of the outer tube and thus lock the two tubes mechanically fixed to one another. This has the advantageous effect that not only a number of helically running channels between the first and second tube, but also helically running ridges and grooves on the inner surface of the inner tube arise, so that the passage formed by the interior of the inner tube promotes turbulence of the fluid flowing through. It also causes the inner as well as the outer surface of the inner tube to enlarge and thus heat transfer through the wall of the inner tube and between fluid flowing through the inner tube and through the helical channels formed between the inner tube and outer tube is favored.

In the production of the tube unit according to the invention, a mandrel is stuck through the inner tube before it is subjected to a twisting pair of torques, so that the growth directed radially inwards of the ridges projecting radially inwards is limited. By precise choice of the diameter and the thicknesses of the tubes and the diameter of the mandrel, the forms of the helically running corrugations formed in the inner tube are controlled relatively precisely and, in so far as desirable, the grooves in the outer surface of the inner tube can be formed so that they receive flat bases of noticeable axial length, so that the helically running channels formed between the inner and the outer tube receive relatively large cross-sections, which permits a relatively high throughput with a minimal drop in pressure.

In so far as desired, a third tube can be used according to the invention that encircles the original two-tube unit and is twisted, so that helically running corrugations form with ridges standing radially inwards that abut the outer surface of the outer tube of the original unit and, in so doing, form a unit that comprises two groups of different helically running channels as well as a helical passage through the innermost tube.

Embodiment examples of the invention are explained in the following with the aid of the drawings. Shown in detail are:

Figure 1 differently cut away in different longitudinal areas, an external view of a tube unit produced according to the process according to the invention,

Figure 2 a cross-section according to the section line 2-2 of Figure 1,

Figure 3 differently cut away in different longitudinal areas, an external view of a tube unit produced according to another embodiment example of the process according to the invention,

Figure 4 differently cut away in different longitudinal areas, an external view of a tube unit produced according to still another additional embodiment example of the process according to the invention,

Figure 5 a lateral view of a form of embodiment of a device for carrying out the process according to the invention for producing a tube unit,

Figure 6 a longitudinal section through an arrangement that shows how the two tubes are joined before the torsion process,

Figure 7 a representation similar to Figure 6 that, however, shows which relative positions the tubes and the mandrel assume at one point in time during the torsion process,

Figure 8 is an enlarged spatial representation of an end piece of the inner tube according to Figure 6 that shows the embossing applied before the torsion process,

Figure 9 is a representation similar to Figure 6 that, however, shows how tubes are disposed before a third tube is twisted onto the outer surface of the tube of greater diameter according to Figure 6 in order to produce a three-tube unit.

In Figures 1 to 4 of the drawings, several different tube units are shown that are produced according to the process according to the invention, and Figures 5 to 9 relate to the process itself. As explained in more detail below in connection with Figures 1 to 4, a tube unit embodying the invention consists of two or more concentric tubes of which at least one is helically corrugated. Each of these tubes preferably consists of metal. Depending on the nature and on the temperature of the fluid to be conducted through, and based on various other considerations, several different metals can also be used. In general the tubes are made of copper, aluminum, or stainless steel but the invention is not limited to these especially cited metals.

Figure 1 shows a tube unit, denoted overall as 10, which consists of a first tube 12 and a second tube 14. The tube 12 has essentially a circularly cylindrical structure, so that its diameter and cross-sectional form are constant over its entire length. The second tube 14 has two end areas 16,

which both project beyond the adjacent ends of the first tube 12 and also have a constant diameter and a uniform cross-sectional form along their entire longitudinal range. Between the two end areas 16 and within the tube 12, the tube 14 has an area with helically running corrugations that, on the outer surface of the tube 14, form a number of corrugation ridges 18 standing radially outwards and extending along a helical path and a corresponding number of helical, flat grooves 20. Complementary to the ridges and grooves on its outer surface, the tube 14 has, on its inner surface, a plurality of helically running grooves 22 and helically running flattened ridges 24 extending radially inwards. The helical ridges 18 standing radially outwards on the outer surface of the tube 14 abut the inner surface 26 of the tube 12 closely and connect thereby the two tubes 12 and 14 to one another in this position. Furthermore, a number of helically running channels 28 between the two tubes 12 and 14 are formed by the close abutment of the ridges 18 against the inner surface of the tube 12. If a fluid is thus conducted in at one end of the tube 12, then it is forced, in the course of its flow to the other end, to flow through the helically running channels, where it becomes turbulent and is brought for heat exchange in good contact with the outer surface of the tube 14.

The number of the helically running channels formed between the two tubes can be different as a function of the number of the separate, continuous, helical ridges 18 formed in the tube 14. In general, the tube 14 is formed so that two, three, or four of such continuous ridges extend over its length that accordingly form two, three, or four

helically running channels between the two tubes. As can be seen best from Figure 2, the tube unit comprises, according to Figure 1, three continuous ridges 18 and thus forms three helically running channels 28 between the two tubes.

The cross-sectional form of the channels 28 can be changed by changing the cross-sectional form of the grooves 20 in the tube 14. Preferably, the grooves 20 are formed so that they have an essentially flat base with a certain axial length, as is shown in Figure 1. Therein, it is particularly to be preferred to make the length of the flat base of each groove 24 noticeably larger in its longitudinal section than the length of the ridge 18 that lies between each two flat groove bases. This provides to each channel 28 a significant cross-section that permits the fluid to flow through with a significant volume per unit of time and with a minimal drop in pressure.

In the tube unit 10 according to Figure 1, the first tube 12 has an essentially circularly cylindrical structure and, to the extent that it is deformed, this deformation merely amounts to a slight deviation from the circularly cylindrical form. Such a tube unit is often applicable in cases in which, for example, a heat transfer is desired only between a fluid flowing through the helical channels 28 and another fluid flowing through the tube 14. In other cases, a heat transfer between a fluid flowing through the helical channels 28 and another fluid flowing along the outer surface of the tube 12 is required. In such a case, it can be desirable to also deform the outer tube 12 so that it receives a larger surface for heat transfer and to give this surface an irregular structure that promotes turbulent flow. Such a tube unit is represented in Figure 3

and denoted overall by 30. In the case of this tube unit 30, the individual parts, with the exception of the outer tube that has a corrugated form, are similar to the corresponding part of the tube unit 10 according to Figure 1, where, in Figure 3, these parts are provided with the same but primed reference numbers.

With reference to Figure 3, it is to be noted that the outer tube 12' comprises, standing radially outwards, helical corrugation ridges 32 on its outer surface and, extending radially outwards, corresponding helical grooves 34 on its inner surface where the grooves 34 receive, with a good fit, the outer elevations of the helical ridges 18' of the outer surface of the inner tube 14'. The form lock between the ridges 18' and the grooves 34 serves therein for a still more secure locking together between the tow tubes engaging in one another. As emerges from the following still more clearly, the helical ridges 32 and grooves 34 of the tube 12' are practically formed by the ridges 18' of the tube 14', while tube 14' is turned in the production of the tube unit 30 in order to form the corrugations. Through precise selection of the wall thicknesses of the two tubes and the diameters of the two tubes and the mandrel, the outer tube can be deformed under control to varying degrees as desired.

Figure 4 shows a tube unit that is denoted overall by 38 and is similar to the tube unit 10 according to Figure 1, with the exception of the fact that it contains a third tube 40 that encircles the tube 12 according to Figure 1. The tube 40 is corrugated and comprises, on its inner surface, ridges 42 standing radially inwards that abut the outer surface of the tube 12 and form a frictional lock between the tube 40 and the tube 12, where several helical running channels 43 between theses two tubes arise. In the case of the tube unit 38, a first fluid can thus

be conducted through the inner tube 14, a second fluid through the helically running channels between the two tubes 12 and 14, a third fluid through the helically running channels between the tubes 40 and 12, and finally a fourth fluid along the outer surface of the outer tube 40. Naturally, two or more streams flowing through the unit, or along it, can be combined in one system in which the unit 38 is used and, if desired, can be treated as one flow.

Figure 5 shows a form of embodiment of a device that can be used for the production of a tube unit according to the present invention. This device consists of a bed 44 and a tail stock 46 that is disposed on the bed in such a manner that it can be displaced in the longitudinal direction. A fixed spindle stock 48 comprises a driven chuck 50 that works together with another chuck 52 carried but not drivable by the spindle stock. On the bed 44 a hydraulic cylinder 54 sits with a rod 56 that is connected to the tail stock 46 in order to move it toward or away from the spindle stock. During a torsion process the cylinder 54 drives the tail stock toward the spindle stock and controls the formation of the corrugations in the tube to be processed. For this, suitable hydraulic control devices are provided that are not a part of the object of this invention and that are, in part, indicated and denoted in Figure 5 by 58.

Figure 6 shows the manner in which two tubes and a mandrel are disposed relative to one another in the device according to Figure 5 at the beginning of the process forming the corrugations that has, as its goal, a tube unit like the unit 10 according to Figure 1. According to this figure, the inner tube 14 in its initial, still not deformed state is fitted between the two chucks 50 and 52 that engage it at its outer ends. A mandrel 60 with an outer diameter

that is noticeably smaller than the inner diameter of the still not deformed tube 14, is inserted into the tube 14 and is preferably held by means of two centering sleeves 62 in a coaxial position relative to the tube, where the mandrel can be displaced in the longitudinal direction at least relative to the left sleeve 62. The centering sleeves 62 are, however, not absolutely necessary since, as soon as the turning process takes place, the corrugations formed from the tube 14 and abutting the mandrel have, in general, a self-centering effect on the mandrel. Thus, the mandrel can in many cases be laid into the tube 14, if desired simply loose, before the beginning of the torsion process. The outer tube 12 is pushed over the tube 14 and disposed near to one of the two chucks that causes, during the turning process, the formation of the corrugations and this is the right chuck in Figure 5. Before the torsion process begins, the tube 12 can, if desired, be held with the aid of a centering device in coaxial position relative to the tube 14 but this is not absolutely necessary since, when the corrugations are formed in the tube 14, their contact with the inner surface of the tube 12 exerts a self-centering effect on the tube 12.

It is also to be pointed out that, before beginning the torsion process, the tube to be deformed preferably has a number of embossings in the vicinity of one end of the tube that form a start for the grooves to be formed during the torsion process in the outer surface of the tube. The number of the embossings provided determines the number of the continuous grooves that are formed in the tube during the twisting and preferably any embossing is extended longitudinally and placed so that it corresponds essentially to the path of the groove starting from it and to be formed later. Figure 8 shows, at 64, different such embossings formed in the tube 14.

After the tubes and the mandrel are joined together with the chucks 50 and 52 as shown in Figure 5, the chuck 50 is turned with respect to the fixed chuck 52 in order thus to twist the tube 14 and, so long as this torsion process takes place, the tube is deformed into helically running corrugations, where the helical ridges and grooves thus formed advance continuously, beginning at the original embossings 64, toward the chuck 50 when the chuck 50 rotates. This deformation of the tube 14 causes the arching of the helical ridges 18 on the outer surface of the tube 14 and an arching directed inwards of the ridges 24 on the inner surface of the tube. The growth directed radially outwards of the ridges 18 standing outwards is limited by the abutment of these ridges on the inner surface of the outer tube 12 and the growth directed radially inwards of the ridges 24 is limited by the abutment of the same on the outer surface of the mandrel 60, where, by the choice of the diameter of the mandrel, the axial length of the grooves 20 with flat base can be determined precisely.

After the conclusion of the torsion process and as a result of the twisting treatment, the outer tube 12 is fastened in its position relative to the inner tube 14 as a consequence of the close abutment of the ridge 18 of the inner tube against the inner surface of the outer tube. Likewise, the mandrel is firmly engaged by the radially inward projecting ridges 24 of the inner tube. Before the mandrel and the tube unit are taken out of the turning device, the clamp of the mandrel is preferably loosened by slight opposite twisting of the tube 14, by the turnable chuck 50 being turned by a small angle in the opposite direction. That loosens the mandrel and makes it possible to draw it out more easily after it is withdrawn from the chucks 50 and 52.

For the production of a three-tube unit, like the unit 38 in Figure 4, the outer tube 40 is used in addition and combined with the tube 12 by the fact that the outer tube 40 is twisted and the tube 12 is used in the sense of a mandrel. This corrugating of the outer tube 40 and its simultaneous connection to the tube 12 can be carried out either before or after the inner tube 14 is corrugated and connected to the tube 12, preferably, however, the outer tube 40 is only twisted after the twisting of the inner tube 14. Figure 9 shows, for example, an outer tube 40 in its original, still not deformed state and joined to the tube 12 that already contains a corrugated inner tube 14 connected to it. The tube 40 is held in the chucks 50 and 52 and the tube 14 is disposed within the tube 40 and held by means of two centering sleeves 66 in a concentric position with respect to it. At one end of the tube 40, suitable embossings are formed. Then, the chuck 50 is turned with respect to the chuck 52 in order to lay corrugations in the tube 40 and to connect it thereby to the tube 12 and to produce the complete three-tube unit represented in Figure 4.

Claims

Claims

1. Process for the production of a tube unit, characterized by the fact that, starting from a first tube (12), a second tube (14) with a noticeably smaller outer diameter than the inner diameter of the first tube and a mandrel (60) with a noticeably smaller outer diameter than the inner diameter of the second tube, the first and second tube and the mandrel are joined together so that the mandrel extends through the second tube and the second tube extends through the first tube, that thereafter the second tube (14) is twisted by means of a pair of torques acting at two points of its length in order to form helically running corrugations that form first ridges (18) on the outer surface of the second tube and second ridges (24) on the inner surface of the second tube, that the growth directed radially outwards of the first ridges (18) during twisting is limited by their abutment against the inner surface of the first tube, and that the growth directed radially inwards of the second ridges (24) during turning is limited by their abutment against the outer surface of the mandrel (60).

2. Process according to Claim 1, characterized by the fact that a number of embossings (64) distributed over the circumferential surface are formed in the second tube (14) at an end area, where all the embossings have essentially the same spacing from the end of the tube, that these embossings are applied before the twisting of the second tube so that they serve as starting points for helical grooves that are formed in the outer surface of the second tube during the twisting.

3. Process according to Claim 1, characterized by the fact that the second tube (14), after twisting, is twisted in the opposite direction in order to loosen the second tube from the fixed clamping to the mandrel (60), and that thereafter the mandrel is drawn out of the second tube.

4. Process according to Claim 1, characterized by the fact that a third tube (40) with a larger inner diameter than the outer diameter of the first tube (12) is pushed over the first tube, that the third tube is twisted by means of a pair of torques acting at two points of its length in order thereby to form helically running corrugations that form ridges (42) on its inner surface, and that the growth directed radially inwards of the ridges (42) during twisting is limited by their abutment against the outer surface of the first tube (12).

[see source for 2 pages of drawings]